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A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images

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► **To cite this version:**

Kinan Abbas, Matthieu Puigt, Gilles Delmaire, Gilles Roussel. A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images. 8ème Journée Régionale des Doctorants en Automatique et Traitement du Signal (JRDA), Jun 2022, Douai, France. hal-03685172

HAL Id: hal-03685172

<https://hal.science/hal-03685172v1>

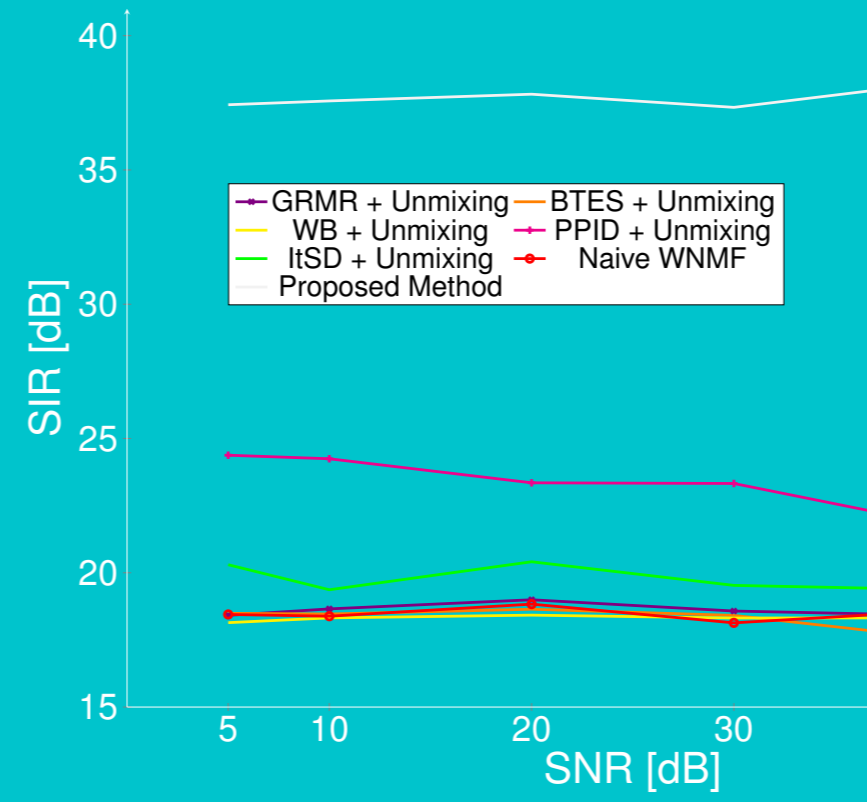
Submitted on 13 Jun 2023

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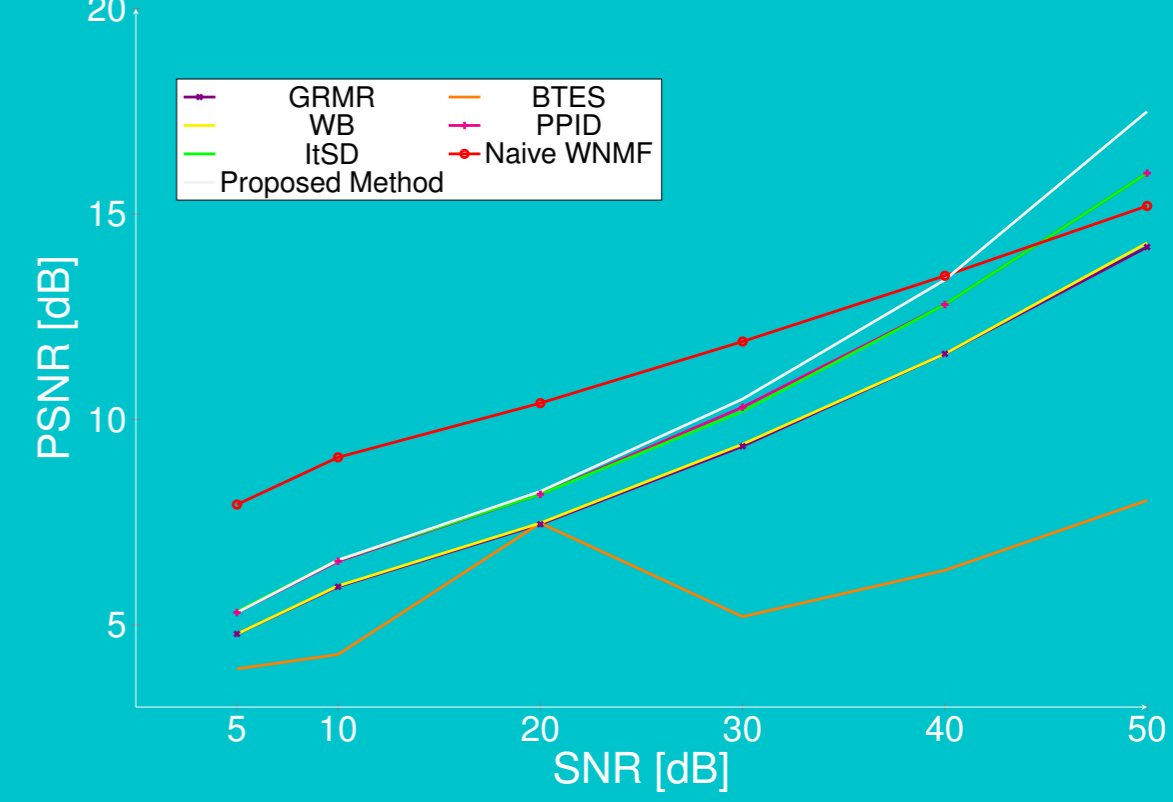
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Performing unmixing after demosaicing SSI images is not a good strategy. Instead, unmixing from the SSI data is far better!

Unmixing performance



Demosaicing performance



A Dedicated Joint Unmixing and Demosaicing Method for Snapshot Spectral Images

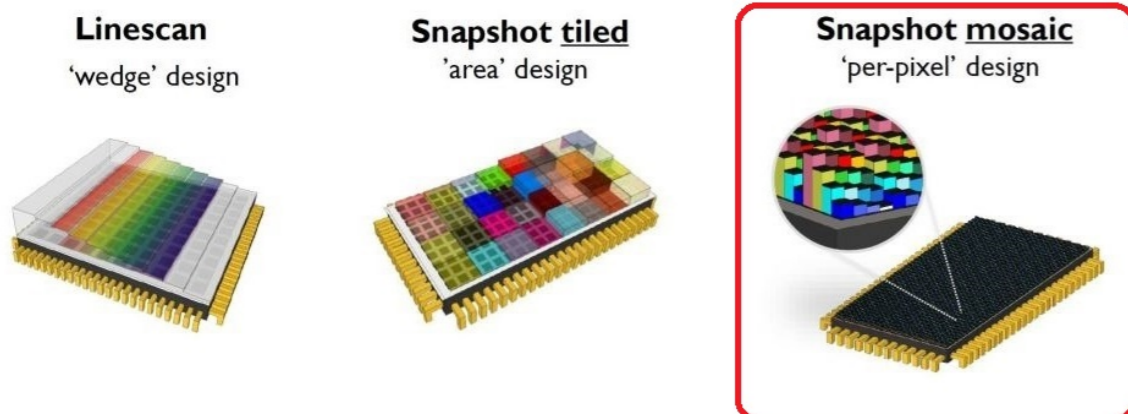
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Snapshot Spectral Imaging (SSI)

- Strategies for miniaturized HSI sensors (on the left for images, middle and right for videos – Source IMEC).



- Demosaicing = providing a datacube combining full spectral information & good spatial resolution**
- Various approaches have been proposed:
 - Weighted bilinear interpolation (WB)
 - Iterative Spectral Difference (ITSD)
 - Multispectral demosaicing approach using a pseudo-panchromatic image (PPIID)
 - Binary Tree-Based Generic Demosaicing (BTES)
 - Graph and rank regularized method (GRMR)

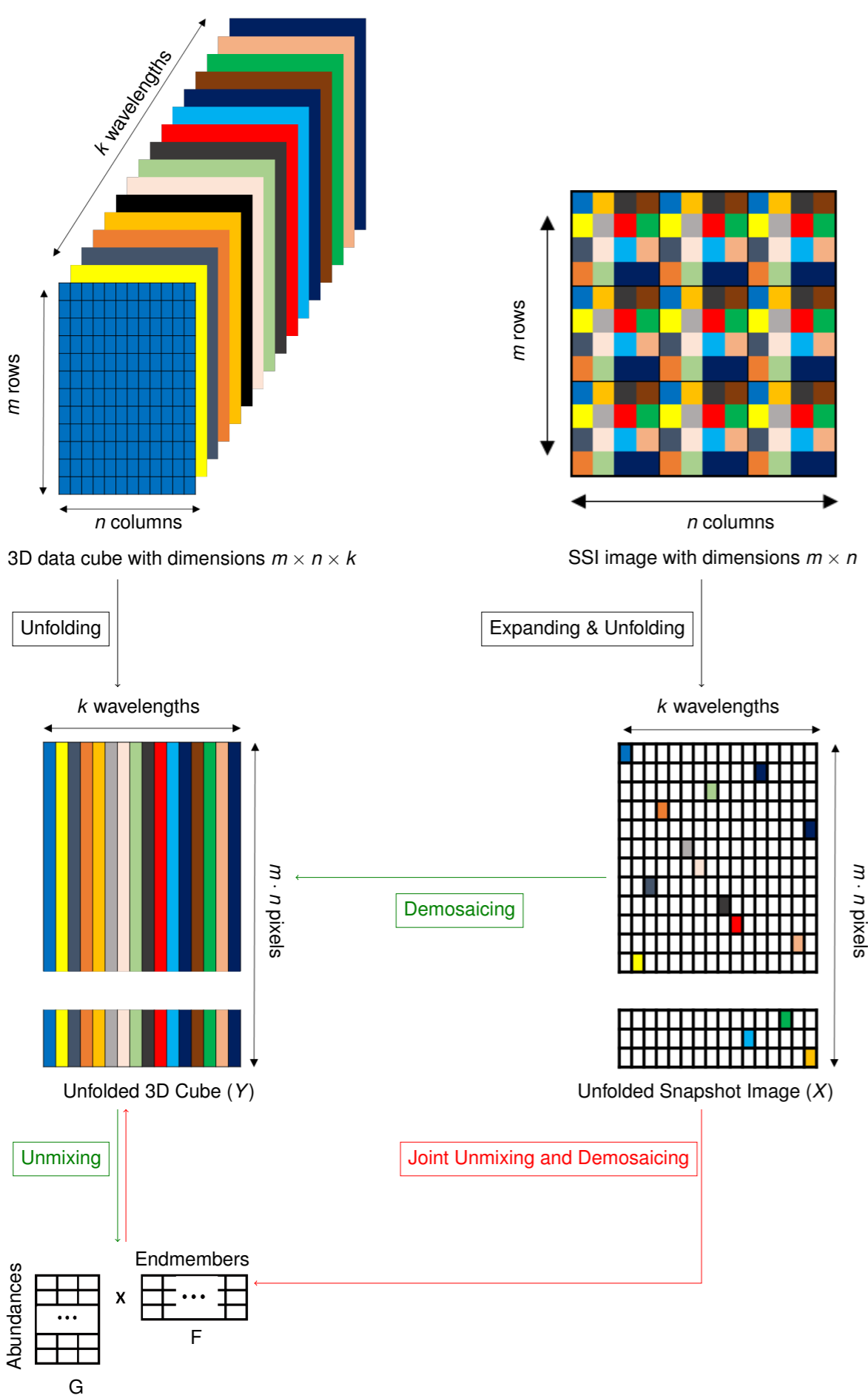


Figure: Principles of the two-step (in green) and joint (in red) strategies.

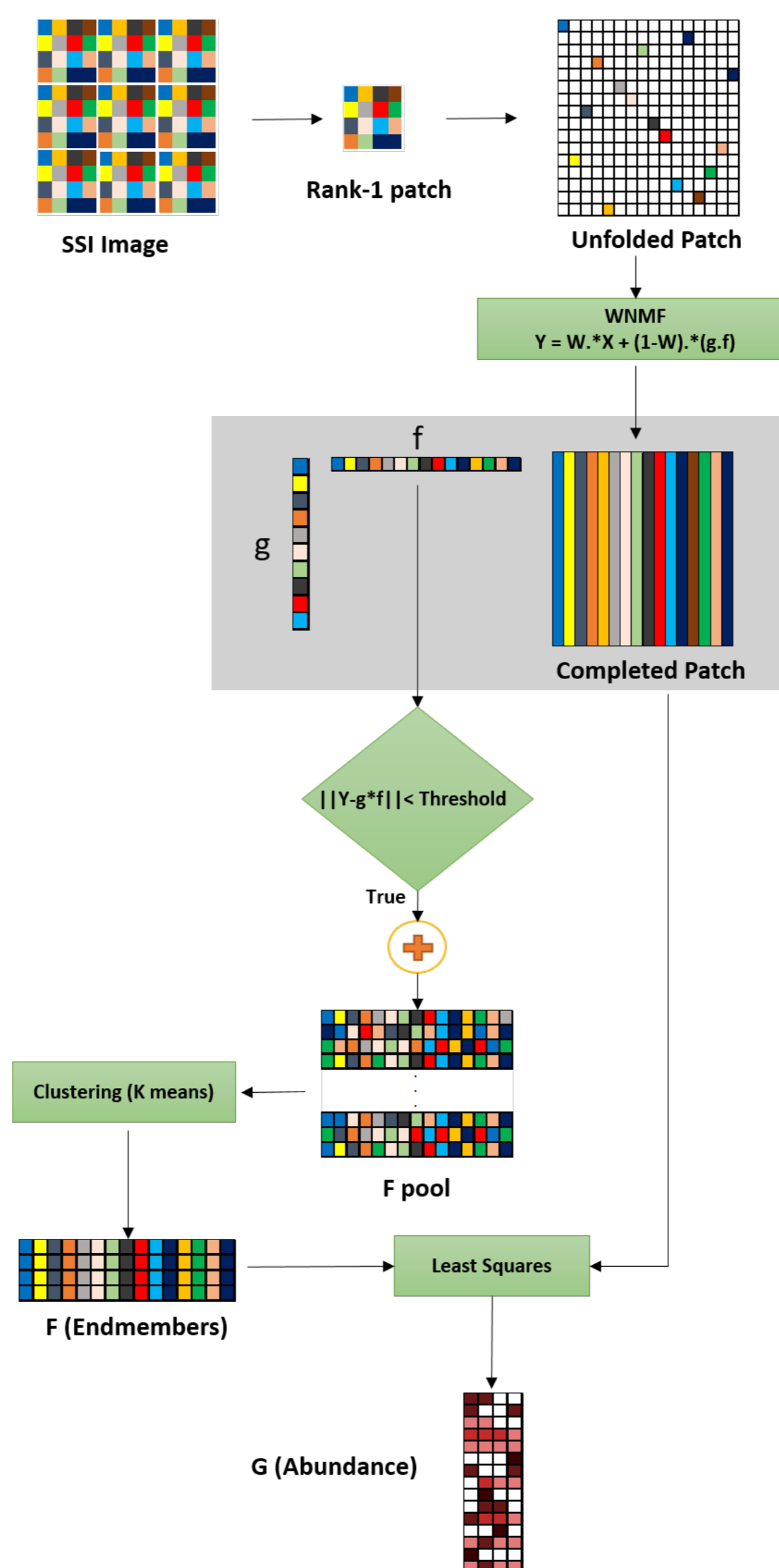
- ⚠ **Performing classification after demosaicing provides a poor classification performance [1]**
- ▶ In [2], **joint** low-rank matrix completion and factorization **far more accurate** than a two-stage approach.
- ⚡ **Joint Demosaicing and Unmixing more efficient than a two-stage approach?**

Naive Method

- Weighted Non-negative Matrix Factorization (WNMF) is used to solve the joint demosaicing and unmixing problem.
$$\hat{Y} = W \circ X + (\mathbb{1}_{(m,n) \times k} - W) \circ (G \cdot F), \quad (1)$$
- W denotes a binary weight matrix whose nonzero entries allow to select which wavelength is observed by the camera in the case of ideal filter.
- W denotes the contributions of each wavelength in the observed wavelength in the case of the real filter.
- Can be solved using Expectation Maximization WNMF framework [3].

Proposed Low-rank Completion-Based Method

- Patch-based rank-1 completion WNMf method (KPWNMF) [4]
 - Assumes some local abundance sparsity
 - Finds locally rank-1 patches which correspond to almost "pure patches"
 - Assumption recently relaxed [5]



Real Filter Harmonics Problem

- Fabry-Perot filters introduce additional harmonics around each wavelength of interest in real implementation.
- These filters are known and are provided by the camera manufacturers.
- Our proposed method takes these harmonics into consideration.

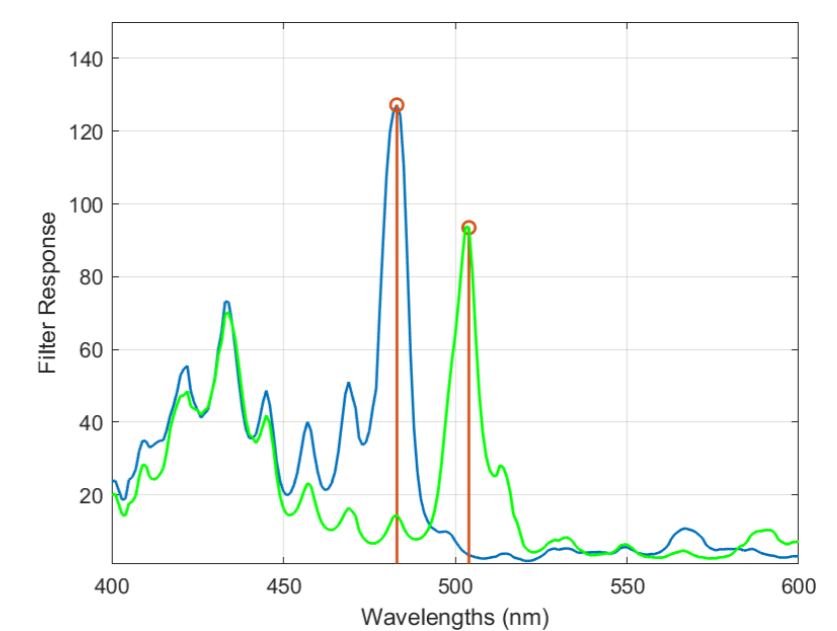


Figure: Ideal (in red) and real (in blue and green) spectral response of two Fabry-Perot filters of the 4 × 4 IMEC SSI camera.

Experiment and Results

- To validate the performance of the proposed approach, we conduct an experiment on Jasper Ridge image.
- We assume that the hyperspectral imagery is acquired using a SSI camera system, equipped with 5 × 5 and 4 × 4 spectral filter patterns.
- Simulations assuming an ideal and real snapshot mosaic filters.
- Reconstruction quality is measured in terms of Peak Signal-to-Noise Ratio (PSNR, in dB) while the unmixing enhancement is measured using Signal-to-Interference Ratio (SIR, in dB).
- Far better unmixing performance** reached by our proposed approach than with 2-stage techniques and naive WNMf
- Still **demosaicing similar** or slightly better than SotA methods

Conclusion and Future Work

- The proposed method provides a slightly better demosaicing performance than state-of-the-art methods and a much higher unmixing enhancement.
- We aim to investigate the use of our proposed methods on real SSI data.
- We also aim to extend them to the case when endmember spectral variability is met in the acquisition process.

Acknowledgements and References

This work was partly funded by the Région Hauts-de-France. Experiments presented in this work were carried out using the CALCULCO computing platform, supported by SCoSI/ULCO.

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